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Title:

COPE/DRAG INTERFACE SEALING ARTICLE FOR THE METAL CASTING
INDUSTRY, AND METHOD

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COPE/DRAG INTERFACE SEALING ARTICLE FOR THE METAL CASTING INDUSTRY, AND METHOD

Field of the Invention

[0001] The present invention is directed to a fiber-reinforced clay-containing article for use in the foundry industry in the casting of molten metal. More particularly, the present invention is directed to an article in the form of a rope, pellet, particle bulk form particularly useful to provide a seal between an upper mold portion (cope) and lower mold portion (drag) to fill in, or correct irregularities in molds, particularly in green sand molds. In casting metal shapes in a sand/binder mold, the cope and/or drag mold portions include sand compositions that are not perfectly planar surrounding the mold cavity, leaving one or more areas where the cope and drag are not in contact, or otherwise do not provide a seal surrounding the mold cavity. The fiber-reinforced clay-containing article described herein is disposed between the cope and drag to seal the mold cavity in one or more locations surrounding the mold cavity. The composition described herein is capable of shaping by hand, like modeling clay, and the article is preferably in the form of a continuous rope that is flexible, remains hydrated, and can be cut or broken to a desired length and disposed in area(s) where the cope and drag do not make good mating contact.

Background and Prior Art

[0002] Sand molds are one of two kinds: (1) "green" sand molds are smectite clay/water bonded sand mixtures rammed against a pattern to form a desired contour (a top half or cope and a bottom half or drag are hooked together to form a complete mold cavity). The sand is a tough, pliable mixture which will hold its molded shape. Molten metal is poured into the mold cavity where it solidifies to form the resultant casting; and (2) "rigid" molds are sand mixtures which can be molded against a pattern and then hardened into a rigid condition. The method of hardening depends on the kind of binder used. Although smectite clay bonded molds can be hardened by air-drying or baking, usually rigid molds are bonded with organic resins which harden into much stronger and harder shapes. Binders are designed to be hardened by several methods. Some are baked; some are cured or hardened by chemical reaction with a reagent; and some are hardened by flushing with a reactive gas.

[0003] Green sand molding is the production of molded metal objects from tempered molding sand and is the most diversified molding process used to cast ferrous as well as non-

ferrous metal castings. Green sand molding is favored by foundry personnel because it is economical and permits both quality and quantity production, particularly for smaller castings. Castings as large as three to four tons are made successfully in green sand molds; however, as molds become larger, more time is required for the making and assembling of mold parts, consequently, other types of molding are generally favored for the larger castings. The rapid collapsibility of green sand molds makes them much less resistant to the normal contraction of the castings while metal solidification takes place, thus minimizing problems of stresses and strains. Green sand is defined as a water tempered molding sand mixture with plasticity. A green sand mold used for casting iron and steel usually consists of silica sand, a clay binder, and/or an organic binding agent mulled together with temper water and a coal additive. Other useful foundry sands including chromite, zircon and olivine sands. U.S. patent numbers 2,830,342 and 2,830,913 are directed to the excellent thermal stability of carbon sands. These sands are also used to make green sand molds.

[0004] Cores are sand shapes which are positioned inside the mold to shape the inside of a casting. If a core were not used, the casting would be solid metal and many castings are not solid, but have inside channels or configurations. Cores are usually rigid shapes employing the same kinds of binders and methods described above for rigid molds.

[0005] One or more binders mixed with the sand are essential to maintain the sand in a predetermined mold configuration. One of the most commonly employed green sand binders is clay, such as a water-swellable sodium bentonite clay or a low swellable calcium bentonite clay. The amount of the clay binder that is used together with the sand generally depends upon the particular type of sand used in the mixture and the temperature of pouring. Silica sand grains expand upon heating. When the grains are too close, the molding sand moves and expands causing the castings to show defects such as "buckles" (a deformity in the casting resulting from excessive sand expansion), "rat tails" (a rough, irregular depression that appears on the surface of a casting or a minor buckle), and "scabs" (a breaking away of a portion of the molding sand when hot metal enters the mold). To overcome this harmful expansion, more clay is added to the sand mixture since the clay contracts upon heating, thereby compensating for the expansion of the silica sand grains. In green sand molding, the reproducibility of the dimensions obtained on the casting are the result of such factors as shrinkage, changes in dimensions of mold cavity, hardness of mold, stability of molding sand, mechanical alignments of flask and maintaining a fixed temperature.

[0006] The cavity in the sand is formed by using a pattern (an approximate duplicate of the part to be molded), which is typically made out of wood, sometimes metal. The cavity is contained in an aggregate housed in a box called the flask. The casting starts with the construction of a pattern, an approximate duplicate of the final casting. The molding sand composition is then packed around the pattern, and the pattern is removed to produce a mold cavity. In a two-part mold, the cope is the top half of the pattern, flask, mold or core. The drag is the bottom half. A core is a sand shape that is inserted into the mold to produce internal features on a casting, such as holes or passages for water cooling. A core print is the region added to the pattern, core, or mold that is used to locate and support the core within the mold. The mold material and the core then combine to form the mold cavity, the void into which the molten metal will be poured and solidified to produce the desired casting. A riser is an extra void created in the mold that will be filled with molten metal. It provides a reservoir of molten metal that can flow into the mold cavity to compensate for any material shrinkage that occurs during solidification. Any shrinkage voids should then be in the riser and not in the final casting.

[0007] The gating system is the network of channels used to deliver the molten metal from outside the mold into the mold cavity. The pouring cup is the portion of the gating system that initially receives the molten metal from the pouring vessel and controls its delivery to the rest of the mold. The vertical part of the gating system connected to the pouring cup is the sprue, the horizontal portions are called the runners, and the multiple points where the molten metal is introduced to the mold cavity are called the gates. Additionally, there are extensions to the gating system called vents that provide a path for built up gases and the displaced air to vent to the atmosphere. The cavity is usually made oversize to allow for the metal to contract as it cools down to room temperature. From the pouring cup, the metal travels down the sprue (the vertical portion of the gating system), then along the horizontal runners, and finally through controlled entrances, or gates, into the mold cavity. A parting line or parting surface is an interface that separates the cope and drag halves of the mold, flask, or pattern, and the halves of a core during some core-making processes. Sand castings generally have a rough surface sometimes with surface impurities, and surface variations. A machining (finish) allowance is made for this type of defect.

[0008] Typically the drag is first filled partially with the sand composition, and the core print, the cores, and the gating system are placed near the parting line. The cope is then

assembled to the drag, and the sand composition is poured into the cope half, covering the pattern, core and gating system. The sand is compacted by vibration and mechanical means and the sand is flattened to provide planar, mating surfaces surrounding the mold cavity on both the cope and drag to provide sealing contact at the interface. Next, the cope is removed from the drag, and the pattern is carefully removed. The object is to remove the pattern without breaking the mold cavity. This is facilitated by designing a draft, a slight angular offset from the vertical, to the vertical surfaces of the pattern. This is usually a minimum of 1° or 1.5 mm (0.060 in), whichever is greater. The rougher surface of the pattern, the more the draft to be provided.

[0009] The cope and drag are not always in sealing contact surrounding the mold cavity at their interface and, particularly in smaller foundries, compressible asphaltic sealing materials, in rope form, are disposed in low areas of the cope/drag interface to provide molten metal sealing in an attempt to minimize the amount of surface finishing required as a result of molten metal overflow surrounding the mold cavity. This asphaltic sealing material is sometimes called a "cope rope". A major problem with the asphaltic cope rope is that the high temperature of the molten metal will volatilize the volatilizable asphalt components, particularly benzene, leading to EPA violations and hazardous working conditions for foundry personnel. In addition, the non-volatilized portion of the asphaltic cope rope leaves tar-like lumps in the foundry sand composition that must be screened out of the sand composition for reuse of the sand composition to mold subsequent parts. The composition and articles described herein provide excellent sealing at the cope/drag interface, do not emit, or emit substantially less, benzene or other VOCs upon contact with molten metal, and can be mixed with the molding sand composition for reuse, without removal, e.g., by screening.

SUMMARY

[0010] In brief, there is described herein a new and improved fiber-reinforced composition and article for use at an interface, between upper and lower mold portions in casting metal parts in the foundry industry. The composition comprises about 35% to about 65% by weight clay, preferably a smectite clay such as sodium montmorillonite, water in an amount about 5% to about 15% by weight; a hygroscopic agent, such as glycerin, in an amount of about 20% to about 60% by weight; and reinforcing fibers, synthetic or natural, such as cotton fibers. The fiber-reinforced composition is formed into an article, preferably in the form of a

rope useful to provide a seal between an upper sand mold portion (cope) and lower sand mold portion (drag) to fill in, or correct irregularities in sand molds, particularly in green sand molds. In casting metal shapes in a sand/binder mold, the cope and/or drag mold portions include sand compositions that are not perfectly planar surrounding the mold cavity, leaving one or more areas where the cope and drag are not in contact or otherwise do not provide a seal surrounding the mold cavity. The fiber-reinforced clay-containing article described herein is disposed between the cope and drag to seal the mold in one or more locations surrounding the mold cavity. The composition described herein is capable of shaping by hand, like modeling clay, and the article is preferably in the form of a continuous rope that is flexible, remains hydrated, and can be cut or broken to a desired length and disposed in area(s) where the cope and drag do not make good mating contact.

[0011] Accordingly, one aspect of the compositions, articles and methods described herein is to provide a new and improved sealing composition for use in sealing one or more areas surrounding a mold cavity in the molding of metal parts;

[0012] Another aspect of the compositions, articles and methods described herein is to provide a sealing composition for the foundry industry useful for minimizing molten metal that flows outside of a mold cavity, said composition comprising clay, water, a hygroscopic agent and reinforcing fibers;

[0013] Another aspect of the compositions, articles and methods described herein is to provide a sealing composition having a consistency of modeling clay, that retains water, that can be in bulk or rope form and is capable of being shaped to any dimensions for filling imperfections in metal casting molds surrounding a mold cavity, or surrounding a portion of the mold cavity;

[0014] Another aspect of the compositions, articles and methods described herein is to provide a sealing article useful for sealing mold cavities in the casting of molten metal that produces substantially less volatile organic compounds (VOCs), particularly less benzene emissions than prior art sealing articles used in the metal casting industry;

[0015] Still another aspect of the compositions, articles and methods described herein is to provide a sealing article for sealing imperfectly formed mold cavities whereby the sealing

article can be reused after metal casting by mixing the used sealing article into a sand composition initially used to form the mold cavity.

Brief Description Of The Drawings

[0016] The above and other aspects and advantages of the compositions, articles, and methods described herein will become more apparent from the following detailed description, taken in conjunction with the drawings, wherein:

[0017] Fig. 1 is a perspective view of a mold formed in a sand/binder composition used to cast metal parts;

[0018] Fig. 2 is a perspective view, taken through the line 2-2 of Fig. 1, of a lower (drag) portion of the mold of Fig. 1 showing the article described herein, in rope form, disposed adjacent to a lower mold cavity; and

[0019] Fig. 3 is a perspective view of the article described herein, in a coiled rope form.

Detailed Description of the Preferred Embodiment

[0020] Throughout this specification, ranges may be expressed herein as from "about" or "approximately" one particular value and/or to "about" or "approximately" another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about," it will be understood that the particular value forms another embodiment.

[0021] In brief, there is described herein a new and improved fiber-reinforced composition and article for use at an interface, between upper and lower mold portions, in casting metal parts in the foundry industry. The compositions used to form the sealing articles described herein comprise about 35% to about 65% by weight clay, preferably a smectite clay such as sodium montmorillonite, water in an amount about 5% to about 15% by weight; a hygroscopic agent, such as glycerin, in an amount of about 20% to about 60% by weight; and reinforcing fibers, synthetic or natural, such as cotton fibers. The fiber-reinforced composition is formed into an article, preferably in the form of a rope useful to provide a seal between an upper sand mold portion (cope) and lower sand mold portion (drag) to fill in, or correct irregularities in sand molds, particularly in green sand molds. In casting metal shapes

in a sand/binder mold, the cope and/or drag mold portions include sand compositions that are not perfectly planar surrounding the mold cavity, leaving one or more areas where the cope and drag are not in contact or otherwise do not provide a seal surrounding the mold cavity. The fiber-reinforced clay-containing article described herein is disposed between the cope and drag to seal the mold in one or more locations surrounding the mold cavity. The composition described herein is capable of shaping by hand, like modeling clay, and the article is preferably in the form of a continuous rope that is flexible, remains hydrated, and can be cut or broken to a desired length and disposed in area(s) where the cope and drag do not make good mating contact.

[0022] Referring now to the drawings, and initially to Fig. 1, there is shown a mold 10 that is formed within a box 12, including an upper flask portion 12A, and a lower flask portion 12B. Each flask portion 12A and 12B is filled with a mold composition 14 comprising sand and a binder, such as sodium bentonite clay, as well known in the art, that surrounds a mold cavity 16.

[0023] The mold cavity 16 in the sand composition 14 is formed by using a pattern (not shown - an approximate duplicate of the part to be molded), which is typically made out of wood, sometimes metal. The molding sand composition is then packed around the pattern, and the pattern is removed to produce the mold cavity 16. The mold cavity 16 includes an upper mold cavity 16A in the top half of the mold, or cope 18, and a bottom mold cavity 16B in the bottom half of the mold, or drag 20. As shown in Fig. 1, the cope 18 includes a riser 22, in fluid communication with the mold cavity 16, forming an extra void in the mold containing molten metal to compensate for any metal shrinkage that occurs during solidification. Any shrinkage voids then are formed in the riser 22 and not in the final casting.

[0024] As further shown in Fig. 1, a gating system 24 provides a network of channels to deliver the molten metal from outside the mold into the mold cavity 16. The gating system 24 includes a pouring cup 26 that initially receives the molten metal from a pouring vessel (not shown) and controls molten metal delivery to the mold cavity 16. The gating system 24 also includes a vertical passage 28, or sprue, that connects the pouring cup 26 to a horizontal (runner) portion 30 of the gating system 24. From the pouring cup 26, the metal travels down the sprue 28, then along the horizontal runners 30, and finally through

controlled entrances, or gates in gating system 24, into the mold cavity 16. As shown in Fig. 1, a parting line or parting surface 34 is the interface that separates the cope and drag halves of the mold.

[0025] When constructing the mold 10, typically the drag 20 is first filled partially with the sand composition, and the core print, the cores, and the gating system 24 are placed near the parting line 34. The cope 18 is then assembled to the drag 20, and the sand composition 14 is poured into the cope half, covering the pattern, core and gating system 24. The sand composition then is compacted by vibration and/or mechanical means and the sand composition is flattened on both the cope 18 and the drag 20 to provide planar, mating surfaces at the interface 34 surrounding the mold cavity 16 on both the cope 18 and drag 20 to provide sealing contact at the interface 34. Next, the cope 18 is removed from the drag 20, and the pattern is carefully removed.

[0026] The cope 18 and drag 20 are not always in sealing contact surrounding the mold cavity 16 at their interface 34. As a result of incomplete mating contact of sand/binder composition 14 at the interface 34 of the cope 18 and drag 20, molten metal sometimes flows over the interface surface 34 requiring expensive and time consuming surface finishing of the cast metal part after removal from the mold cavity 16.

[0027] As shown in Figs. 2 and 3, the fiber-reinforced compositions described herein are extruded in the form of a rope-shaped article 40, separated into a desired length, and positioned at the interface surface 34 at one or more low areas 35, where the cope 18 and drag 20 do not make sealing contact surrounding the mold cavity 16. The article 40 preferably is extruded, and preferably wound into a coil 40A, as shown in Fig. 3. It should be understood, however, that the fiber-reinforced compositions can be mixed in any other manner, *e.g.*, using a Banbury blender, or the like, and can be in bulk form, *e.g.*, disposed in a can or other container for hand, trowel, or putty knife removal, and hand-shaping a desired quantity of the composition into any form. The composition remains hydrated over extended periods of time. The composition and articles 40, 40A described herein provide excellent sealing at the cope 18/drag 20 interface 34, do not emit, or emit substantially less, benzene or other VOCs upon contact with molten metal, and can be mixed with the molding sand composition 14 for reuse, without costly and time-consuming removal, *e.g.*, by screening, after casting.

[0028] The flexible compositions described herein are particularly useful for sealing molten metal in a sand mold, for disposition between an upper mold portion (cope 18) and a lower mold portion (drag 20), and include: clay, preferably a smectite clay, in an amount in the range of about 35% to about 65% by weight; water in an amount in the range of about 5% to about 15% by weight; a hygroscopic agent in an amount in the range of about 20% to about 60% by weight; and reinforcing fibers in an amount of about 0.1% to about 5% by weight. Preferably, the clay is a smectite clay and is present in the composition in an amount of about 40% to about 60% by weight; water is included in an amount of about 7% to about 12% by weight; the hydroscopic agent is included in an amount of about 30% to about 50% by weight; and the reinforcing fibers are included in an amount of about 0.1% to about 1% by weight of the total composition.

[0029] The preferred clays are kaolinite clay and smectite clays, particularly a sodium montmorillonite clay, a sodium bentonite clay, a calcium montmorillonite clay, a calcium bentonite clay, or a combination thereof. A preferred bentonite is sodium bentonite which is basically a hydratable montmorillonite clay of the type generally found in the Black Hills region of South Dakota and Wyoming. This clay has sodium as a predominant exchange ion. However, the bentonite utilized in accordance with this embodiment of the present invention may also contain other cations, such as calcium, magnesium and iron.

[0030] There are cases wherein a montmorillonite predominant in calcium ions can be converted to a high swelling sodium variety through a well-known process called "peptizing". The clay utilized herein may be one or more peptized bentonites. The clay may also be any member of the dioctahedral or trioctahedral smectite group or mixtures thereof. Examples are Beidellite, Nontronite, Hectorite and Saponite. To achieve the full advantage, the clay generally is finely divided or ground as known for use in water barrier panels and the like, *i.e.*, 4 to 350 mesh, preferably 20 to 200 mesh.

[0031] The hygroscopic agent(s) can be any organic material that reduces a water evaporation rate from the composition. The preferred hygroscopic agent is glycerin. Other suitable hygroscopic agents include acetamide MEA; corn syrup; fructose; glucose; glycol; 1,2,6-hexanetriol; honey; hydrogenated honey; hydrogenated starch hydrolysate; inositol; ascorbic acid; lactic acid; lactose; mannitol; polyethylene glycol; polyethylene glycol pentaerythritol ether; 2,6-hexanetriol; propylene glycol; ascorbyl dipalmitate; glucamire;

glycereth; pyrrolidone carboxylic acid; sodium pyrrolidone carboxylic acid; glucose glutamate; sucrose glutamate; fructose; glucuronic acid; glutamic acid; maltitol; sorbitol; methyl gluceth; inositol; polyglyceryl sorbitol; polyvinyl pyrrolidone; sucrose; urea; xylitol; and a combination thereof.

[0032] The reinforcing fibers can be any natural or synthetic fibers. The preferred fibers have a diameter ranging from about 0.05 mm to about 0.25 mm and a length in the range of about 2 mm to about 40 mm. The reinforcing fibers will be pyrolyzed and/or volatilized upon contact with molten metal. The preferred fibers are cotton fibers. Other suitable reinforcing fibers include polyester fibers, wool fibers, wood fibers, paper fibers and the like.